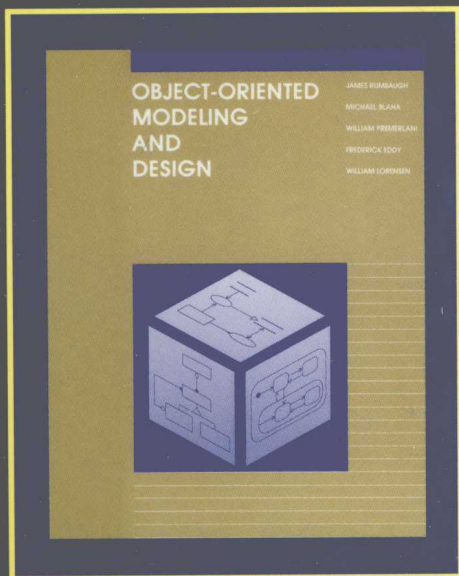


Object-Oriented Modeling and Design

# 面向对象建模与设计

(影印版)

[美] James Rumbaugh 等 著



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[美] James Rumbaugh 等 著

中国电力出版社

Object-Oriented Modeling and Design (ISBN 0-13-629841-9)

James Rumbaugh, Michael Blaha, William Premerlani, Frederick Eddy, William Lorensen

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# Object-Oriented Modeling and Design

James Rumbaugh  
Michael Blaha  
William Premerlani  
Frederick Eddy  
William Lorensen

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# Preface

This book presents an object-oriented approach to software development based on *modeling objects* from the real world and then using the model to build a language-independent *design* organized around those objects. Object-oriented modeling and design promote better understanding of requirements, cleaner designs, and more maintainable systems. We describe a set of object-oriented concepts and a language-independent graphical notation, the Object Modeling Technique, that can be used to analyze problem requirements, design a solution to the problem, and then implement the solution in a programming language or database. Our approach allows the same concepts and notation to be used throughout the entire software development process. The software developer does not need to translate into a new notation at each development stage as is required by many other methodologies.

We show how to use object-oriented concepts throughout the entire software life cycle, from analysis through design to implementation. The book is not primarily about object-oriented languages or coding. Instead we stress that coding is the last stage in a process of development that includes stating a problem, understanding its requirements, planning a solution, and implementing a program in a particular language. A good design technique defers implementation details until later stages of design to preserve flexibility. Mistakes in the front of the development process have a large impact on the ultimate product and on the time needed to finish. We describe the implementation of object-oriented designs in object-oriented languages, non-object-oriented languages, and relational databases.

The book emphasizes that object-oriented technology is more than just a way of programming. Most importantly, it is a way of thinking abstractly about a problem using real-world concepts, rather than computer concepts. This may be a difficult transition for some people because older programming languages force one to think in terms of the computer

and not in terms of the application. Books that emphasize object-oriented programming often fail to help the programmer learn to think abstractly without using programming constructs. We have found that the graphical notation that we describe helps the software developer visualize a problem without prematurely resorting to implementation.

We show that object-oriented technology provides a practical, productive way to develop software for most applications, regardless of the final implementation language. We take an informal approach in this book; there are no proofs or formal definitions with Greek letters. We attempt to foster a pragmatic approach to problem solving drawing upon the intuitive sense that object-oriented technology captures and by providing a notation and methodology for using it systematically on real problems. We provide tips and examples of good and bad design to help the software developer avoid common pitfalls. To illustrate the pragmatic nature of these concepts, we describe several real applications developed by the authors using object-oriented techniques.

This book is intended for both software professionals and students. The reader will learn how to apply object-oriented concepts to all stages of the software development life cycle. At present, there are few, if any, object-oriented books covering the entire life cycle, as opposed to programming or analysis alone. In fact, there are few textbooks on object-oriented technology of any kind. Although object-oriented technology is currently a “hot” topic, most readers have limited experience with it, so we do not assume any prior knowledge of object-oriented concepts. We do assume that the reader is familiar with basic computing concepts, but an extensive formal background is not required. Even existing object-oriented programmers will benefit from learning how to design programs systematically; they may be surprised to discover that certain common object-oriented coding practices violate principles of good design.

The database designer will find much of interest here. Although object-oriented programming languages have previously received the most attention, object-oriented design of databases is perhaps even more compelling and immediately practical. We include an entire chapter describing how to implement an object-oriented design using existing relational database management systems.

This book can be used as a textbook for a graduate or advanced undergraduate course on software engineering or object-oriented technology. It can be used as a supplementary text for courses on databases or programming languages. Prerequisites include exposure to modern structured programming languages and a knowledge of basic computer science terms and concepts, such as syntax, semantics, recursion, set, procedure, graph, and state; a detailed formal background is not required. Exercises of varying difficulty are included in each chapter along with selected answers at the back of the book.

Many object-oriented books primarily discuss programming issues, usually from the point of view of a single language. The best of them discuss design issues, but they are nevertheless mainly about programming. Fewer books address object-oriented analysis or design. We show that object-oriented concepts can and should be applied throughout the entire software life cycle. Recently books on object-oriented methodology have begun to appear. Our book is compatible with other books on object-oriented analysis and design, and we feel that it is complementary to them in content.

Several existing books on software methodology discuss the entire life cycle from a procedural viewpoint. The traditional data flow methodologies of DeMarco, Yourdon, and others are based mainly on functional decomposition, although recent revisions have been influenced by object-oriented concepts. Even Jackson's methodology, which superficially seems to be based on objects, quickly reverts to procedural issues.

Our emphasis differs in some respects from the majority of the object-oriented programming community but is in accord with the information modeling and design methodology communities. We place a much greater emphasis on object-oriented constructs as models of real things, rather than as techniques for programming. We elevate interobject relationships to the same semantic level as classes, rather than hiding them as pointers inside objects. We place somewhat less importance on inheritance and methods. We downplay fine details of inheritance mechanisms. We come down strongly in favor of typing, classes, modeling, and advance planning. We use terminology that is universally accepted when possible, otherwise we try to choose the best terms among various alternatives. There is as yet no commonly accepted graphical notation for object-oriented constructs, so despite concerns about introducing "yet another notation" we use our own Object Modeling Technique notation, which we have used extensively on real problems and which has been successfully adopted by others. In any case, the object-oriented concepts themselves are the most important thing, not the shape of the symbols used to represent them. We also show how to apply object-oriented concepts to state machines.

The book contains four parts. Part 1 presents object-oriented concepts in a high-level, language-independent manner. These concepts are fundamental to the rest of the book, although advanced material can be skipped initially. The Object Modeling Technique notation is introduced in Part 1 and used throughout the book to show examples. Part 2 describes a step-by-step object-oriented methodology of software development from problem statement through analysis, system design, and object design. All but the final stages of the methodology are language-independent; even object design is concerned mostly with issues independent of any particular language. Part 3 describes the implementation of object-oriented designs in various target environments, including object-oriented languages, non-object-oriented languages, and relational databases. It describes the considerations applicable to different environments, although it is not intended to replace books on object-oriented programming. Part 4 presents case studies of actual object-oriented applications developed by the authors at the General Electric Research and Development Center. The problems cover a range of application domains and implementation targets.

The authors have used object-oriented analysis, design, programming, and database modeling for several years on a variety of applications. We have also implemented an object-oriented language, developed an object-oriented notation and methodology, and developed object-oriented support tools, so we are familiar with both theoretical and pragmatic issues of implementing and using object-oriented technology. We are enthusiastic about the object-oriented approach and have found that it is applicable to almost any kind of application. We have found that the use of object-oriented concepts, together with a graphical notation and a development methodology, can greatly increase the quality, flexibility, and understandability of software. We hope that this book can help to get that message across.

## ACKNOWLEDGMENTS

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## Production Note

The manuscript of this book was prepared by the authors on SUN workstations using the FrameMaker document preparation system. We drew the diagrams using the FrameMaker system. We created most object diagrams using our OMTool editor and converted them to FrameMaker format. We performed detailed page layout, made the index, and generated the table of contents using the FrameMaker system. Proof copies of the complete document were printed on Apple LaserWriter Plus printers. We generated PostScript page description files from the final document, copied them onto a Unix *tar* tape, and sent the tape to the publisher for generation of the camera copy on a Linotronic 202 typesetter. The publisher prepared and set the title and copyright pages.



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# Introduction

*Object-oriented modeling and design* is a new way of thinking about problems using models organized around real-world concepts. The fundamental construct is the object, which combines both data structure and behavior in a single entity. Object-oriented models are useful for understanding problems, communicating with application experts, modeling enterprises, preparing documentation, and designing programs and databases. This book presents an object-oriented software development methodology, the Object Modeling Technique (OMT), which extends from analysis through design to implementation. First an analysis model is built to abstract essential aspects of the application domain without regard for eventual implementation. This model contains objects found in the application domain, including a description of the properties of the objects and their behavior. Then design decisions are made and details are added to the model to describe and optimize the implementation. The application-domain objects form the framework of the design model, but they are implemented in terms of computer-domain objects. Finally the design model is implemented in a programming language, database, or hardware.

We describe a graphical notation for expressing object-oriented models. Application-domain and computer-domain objects can be modeled, designed, and implemented using the same object-oriented concepts and notation. The same seamless notation is used from analysis to design to implementation so that information added in one stage of development need not be lost or translated for the next stage.

## 1.1 WHAT IS OBJECT-ORIENTED?

Superficially the term “object-oriented” means that we organize software as a collection of discrete objects that incorporate both data structure and behavior. This is in contrast to conventional programming in which data structure and behavior are only loosely connected. There is some dispute about exactly what characteristics are required by an object-oriented approach, but they generally include four aspects: identity, classification, polymorphism, and inheritance.

### 1.1.1 Characteristics of Objects

*Identity* means that data is quantized into discrete, distinguishable entities called *objects*. A *paragraph in a document*, a *window on my workstation*, and the *white queen in a chess game* are examples of objects. Figure 1.1 shows some additional objects. Objects can be concrete, such as a *file* in a file system, or conceptual, such as a *scheduling policy* in a multiprocessing operating system. Each object has its own inherent identity. In other words, two objects are distinct even if all their attribute values (such as name and size) are identical.

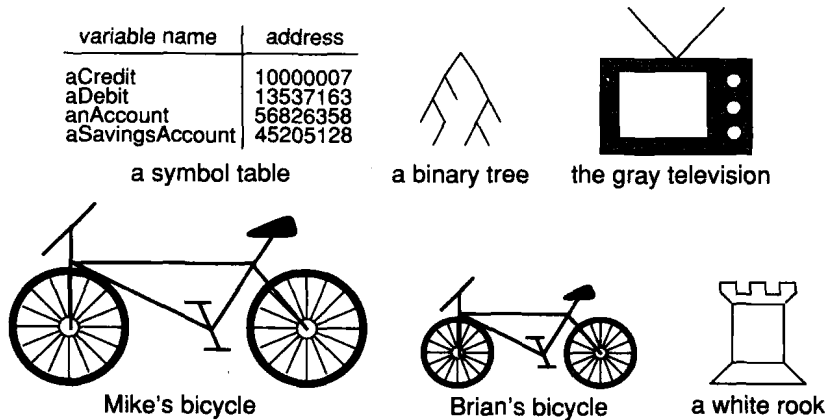


Figure 1.1 Objects

In the real world an object simply exists, but within a programming language each object has a unique *handle* by which it can be uniquely referenced. The handle may be implemented in various ways, such as an address, array index, or unique value of an attribute. Object references are uniform and independent of the contents of the objects, permitting mixed collections of objects to be created, such as a file system directory that contains both files and subdirectories.

*Classification* means that objects with the same data structure (*attributes*) and behavior (*operations*) are grouped into a *class*. *Paragraph*, *Window*, and *ChessPiece* are examples of classes. A *class* is an abstraction that describes properties important to an application and ignores the rest. Any choice of classes is arbitrary and depends on the application.

Each class describes a possibly infinite set of individual objects. Each object is said to be an *instance* of its class. Each instance of the class has its own value for each attribute but shares the attribute names and operations with other instances of the class. Figure 1.2 shows two classes and some of their respective instance objects. An object contains an implicit reference to its own class; it “knows what kind of thing it is.”

*Polymorphism* means that the same operation may behave differently on different classes. The *move* operation, for example, may behave differently on the *Window* and *ChessPiece* classes. An *operation* is an action or transformation that an object performs or is subject to. *Right-justify*, *display*, and *move* are examples of operations. A specific implementation of an



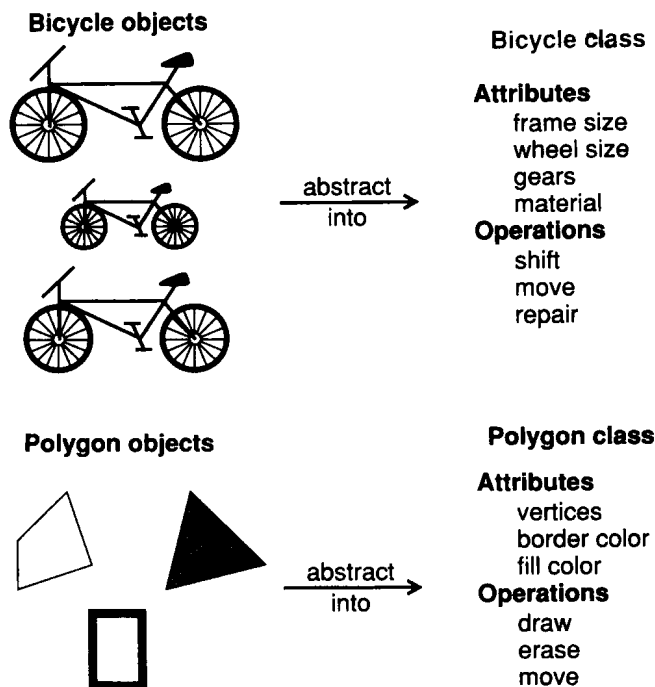


Figure 1.2 Objects and classes

operation by a certain class is called a *method*. Because an object-oriented operator is polymorphic, it may have more than one method implementing it.

In the real world, an operation is simply an abstraction of analogous behavior across different kinds of objects. Each object “knows how” to perform its own operations. In an object-oriented programming language, however, the language automatically selects the correct method to implement an operation based on the name of the operation and the class of the object being operated on. The user of an operation need not be aware of how many methods exist to implement a given polymorphic operation. New classes can be added without changing existing code, provided methods are provided for each applicable operation on the new classes.

*Inheritance* is the sharing of attributes and operations among classes based on a hierarchical relationship. A class can be defined broadly and then refined into successively finer *subclasses*. Each subclass incorporates, or *inherits*, all of the properties of its *superclass* and adds its own unique properties. The properties of the superclass need not be repeated in each subclass. For example, *ScrollingWindow* and *FixedWindow* are subclasses of *Window*. Both subclasses inherit the properties of *Window*, such as a visible region on the screen. *ScrollingWindow* adds a scroll bar and an offset. The ability to factor out common properties of several classes into a common superclass and to inherit the properties from the superclass can greatly reduce repetition within designs and programs and is one of the main advantages of an object-oriented system.